RELATIVE INTENSITY OF OYSTER SETTING IN DIFFERENT YEARS IN THE SAME AREAS OF LONG ISLAND SOUND

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Quantitative studies of marine bottom invertebrates have been conducted since the early part of the century, and the results have substantially enriched our knowledge and understanding of aquatic communities. The contributions of many workers to this important branch of marine biology have been reviewed by several authors, including Spärck (1935) and, more recently, Sanders (1956).

Regardless of the progress made, there still remains one aspect of this field which has been relatively neglected but which should be of special interest to many students of bottom communities. In general, it concerns the recruitment of the new year-classes of such forms as mollusks and echinoderms that have pelagic larvae which, after a free-swimming period, descend to the bottom and metamorphose, the act commonly called setting. In particular, it deals with the variations in the intensity of setting of the same species in the same area in different years, and comparing these variations with those of other, nearby areas.

Our long-term studies of the biological events of Long Island Sound give us the opportunity to discuss certain aspects of this problem in relation to the American oyster, *Crassostrea virginica*. The conclusions are based on data collected during the past 12 years, 1944 through 1955, from ten chosen areas. The locations of these areas, which we shall call stations, are shown in Figure 1. They were confined to three depths— 10, 20 and 30 feet—and represented three major oyster-producing sections of Long Island Sound, namely, New Haven, Milford and Bridgeport. The combined area of these sections is approximately 80 square miles.

The intensity of setting at each of the stations was evaluated by counting the number of recently set oysters on special collectors consisting of wire mesh bags filled with old oyster shells (Prytherch, 1930). This is the standard method in use at our laboratory for over 20 years, and with which most oyster biologists and oystermen are now well familiar (Loosanoff and Engle, 1940; Loosanoff, Engle and Nomejko, 1955). It is important to emphasize that the locations of the stations remained the same during the 12 years, and that the methods of determining the intensity of setting were identical for all stations.

To evaluate the relative productivity of each station, we employed a simple ranking method by giving, each year, Rank 1 to the most productive station, Rank 2 to the next most productive, and so on, until the least productive was given Rank 10. For example, for 1944, Station 1, the most productive, was given Rank 1; Station 2, the least productive, Rank 10; Station 3, Rank 9; etc. (Table I).

To determine the relative productivity of the stations during the entire 12-year period, we expressed the rank of each station as the sum of its yearly ranks (Table I). Naturally, the stations that were generally better producers and, therefore, entitled to low ranks, such as Station 9, showed lower sums than the stations that were less productive. On the basis of this total score, we gave a long-range rank to each station.

The question immediately arose as to whether these ranks would remain approximately the same if the stations were graded for their performance only during the years of better sets, namely, 1944, 1945, 1946, 1953 and 1955. However, our analysis showed that the ranks of the stations for these years were not substantially different from the long-range ranks based on the 12-year observation period (Table I).

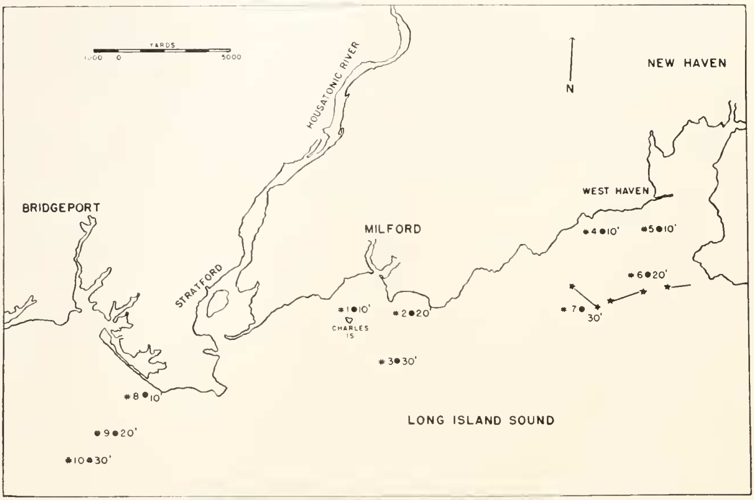

FIGURE 1. Locations and depths (in feet) of ten stations established for observation of oyster setting in Long Island Sound, 1944–1955.

A close study of the data provided information as to the relative importance of the stations, the depths, and the areas in the different years. It was established that, excluding Stations 2, 3 and 4, each station ranked first at least one year out of 12. It was also found that a 10-foot station ranked first, five times; a 20-foot station ranked first, three times; and a 30-foot station, four times. Thus, considering that at the 10-foot depth we have one station more than at 20 or 30, it appears that Rank 1 was occupied by stations of each of the three depths the same number of times.

If we add the sums of the yearly ranks of all the stations at the same depth and then calculate the average sum of the yearly ranks of these depth-groups, we will find that the 10-foot stations have a score of 65.2; 20-foot stations, 57.3; and 30-foot stations, 75.7. Thus, the 20-foot stations seem to be generally somewhat more productive than the others, while the 30-foot stations appear to be the least productive of the groups at all three depths. The latter conclusion, however, may not be well founded because the low rank of the 30-foot stations is chiefly due to the history of setting at Station 3 which, through the 12 years, was consistently one of the poorest, never rising above sixth place; whereas another 30-foot station, Number 10, was, in more than half the instances, among the five best stations, and ranked first on three occasions (Table I).

TABLE I

Rank crder of the sampling stations representing oyster-setting areas of Long Island Sound during the 12-year period, 1944–1955

Areas	Milford			New Haven				Bridgeport		
Stations	1	2	3	4	5	6	7	8	9	10
Depth in feet	10	20	30	10	10	20	30	10	20	30
Years										
1944	1	10	9	5	2	4	7	6	8	3
1945	1	4	8	10	6	5	9	2	3	7
1946	6	9	8	10	5	1	3	7	2	4
1947	7	6	8	9	5	2	10	1	3	4
1948	8	6.5*	10	3	6.5*	5	2	4	1	9
1949	8	4	9	3	5	7	1	2	6	10
1950	7	9	10	8	4	6	2	5	1	3
1951	9	10	7	8	4	6	5	3	2	1
1952	1	5	10	7	4	6	8	3	2	9
1953	7	3	8	10	4.5*	6	9	4.5*	2	1
1954	7	2.5*	9.5**	9.5**	1	5	6	8	4	2.5*
1955	4	5	6	10	7	9	8	3	2	1
Sum of 12 yearly ranks	66	74	102.5	92.5	54	62	70	48.5	36	54.5
Long-range rank, 12 years	6	8	10	9	3	5	7	2	1	4
Rank for 1944, 1945, 1946, 1953, 1955	3	7	9	10	5	6	8	4	2	1

*, ** Indicate a tie between stations for the same rank.

The data were also used to evaluate the relative productivity of the three areas under observation, namely, New Haven, Milford and Bridgeport (Fig. 1). By adding the ranks of all the stations, as given in Table I, for each area and year, and dividing the resulting figure by the number of stations, the average station rank for each area was determined (Table II). Accordingly, each area was given a yearly rank, the one with the lowest score occupying the first or most productive position. The sums of the average yearly ranks for each year, as shown at the bottom of Table II, were also determined. It was found that the Bridgeport area occupied first rank, or the best producing position, nine years out of 12, and never held third or last place. The New Haven area was next, occupying first rank for three years. The Milford area, however, never reached the highest position, ranked second only four times, and was in the third, or lowest position for the remaining eight years.

We cannot offer a fully satisfactory explanation for the variations or, in some instances, stability from year to year in the relative productivity of our stations. Such considerations as original number of eggs discharged; mortality of larvae due to diseases, enemies, or lack of food; and several others are, of course, of importance. Nevertheless, there is little doubt that the intensity of setting of oysters at all stations depends to a large extent upon the peculiarities of the inshore system of water currents.

Table II

Average yearly station-ranks of the New Haven, Milford and Bridgeport areas, and general rank of each of these three areas for each year of 1944–1955 period. Sums of average yearly ranks of stations of each area, and the ranking of the areas during the entire 12-year period are also given

Years	Areas			Ranks		
	New Haven	Milford	Bridge-port	1	2	3
1944	4.50	6.67	5.67	New Haven	Bridgeport	Milford
1945	7.50	4.33	4.00	Bridgeport	Milford	New Haven
1946	4.75	7.67	4.33	Bridgeport	New Haven	Milford
1947	6.50	7.00	2.67	Bridgeport	New Haven	Milford
1948	4.13	8.17	4.67	New Haven	Bridgeport	Milford
1949	4.00	7.00	6.00	New Haven	Bridgeport	Milford
1950	5.00	8.67	3.00	Bridgeport	New Haven	Milford
1951	5.75	8.67	2.00	Bridgeport	New Haven	Milford
1952	6.25	5.33	4.67	Bridgeport	Milford	New Haven
1953	7.38	6.00	2.50	Bridgeport	Milford	New Haven
1954	5.38	6.33	4.83	Bridgeport	New Haven	Milford
1955	8.50	5.00	2.00	Bridgeport	Milford	New Haven
Sum of average yearly ranks	69.64	80.84	46.34	Bpt.—9 yrs. N. H.—3 yrs. Mfd.—0 yrs.	N. H.—5 yrs. Mfd.—4 yrs. Bpt.—3 yrs.	Mfd.—8 yrs. N. H.—4 yrs. Bpt.—0 yrs.

The complexity and characteristics of these currents in the oyster-producing section of Long Island Sound are still relatively unknown because no detailed study has ever been made. We know, however, that planktotrophic larvae, with comparatively longer pelagic lives, like those of oysters and many other pelecypods, are carried by water masses and that their distribution is controlled by the currents. Under certain conditions the direction of the currents may be so changed that the larvae will be carried away from the areas where setting normally takes place, and eventually perish. In other instances, as reported by Coe (1953) for *Donax gouldi,* an enormous increase in the population of a species may occur because swarms of pelagic larvae, about ready to set, are unexpectedly brought inshore by water currents. Hence, it is understandable that the productivity of small areas, such as those designated for our stations, should, in general, be more affected by minor changes in larvae-carrying currents than that of larger areas, such as New Haven, Milford or Bridgeport, which cover many square miles of oyster-producing bottom, and should certainly display more stability in maintaining their relative positions.

These observations emphasize the importance of studying the different aspects of local minor currents, including their direction, velocity and stratifications. They also indicate the importance of understanding the relationship between the behavior of such currents and the locations of the spawning beds, of oysters or other mollusks, where the larvae originate.

Our studies suggest, moreover, that minor currents are often extremely precise in their behavior. This was well demonstrated by observations on the intensity of setting of oysters at our Station 10, located several miles from the shore and in comparatively deep water, but where, nevertheless, heavy setting continued steadily day after day for as long as three or four weeks because the currents consistently brought a supply of ready-to-set larvae to that point. In 1955, this regularity was not noticeably affected even by the strong winds of hurricane "Connie" nor by the winds and record-breaking floods of "Diane." Finally, they imply the potential danger of interfering with established combinations of the favorable ecological conditions existing on the bottom by modifying its contour so as to change the directions of the local currents. Although these changes may not affect commonly studied factors, such as temperature and salinity, they may, nevertheless, so alter the currents that the larvae will be carried to new areas, some of which may not be suitable for their setting.

We wish to express our appreciation to Barbara J. Myers for her assistance in analyzing these data, and to our colleagues, Harry C. Davis and Rita S. Riccio, for their helpful suggestions in preparing this paper.

Summary

1. During the 12 years of observations none of the stations, representing relatively small bottom areas, always occupied a position among the best oyster set producers.

2. If larger areas instead of individual stations were compared, a definite tendency of the Bridgeport area to be more productive than the others was evident.

3. There was no evidence that the stations located at a definite depth, such as 10, 20 or 30 feet, consistently produced better sets of oysters than the stations at other depths.

4. There may be a great variability in the density of oyster set even within a given depth and district in the same year. For example, Stations 4 and 5, although located in the same district and at the same depth, showed a rather different standing with Long-Range Ranks of 9 and 3, respectively.

5. Local minor water currents are important in the relative productivity of bottom areas.

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